JH

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Of Counsel:
LEWIS G. GATCH

August 31, 2005

**VIA OVERNIGHT UPS**

Mr. Richard A. Powers, Chief
Water Bureau
Michigan Dept of Environmental Quality
P.O. Box 30273
Lansing, MI 48909

COPY

RECEIVED
SEP - 2 2005

Re: Williamsburg Receiving and Storage, LLC
WMD Order No. 31-07-02

Dear Mr. Powers:

This letter is in response to your correspondence of July 25, 2005, and August 19, 2005, respectively. I will respond to the issues raised in your July 25, 2005, correspondence first, and in the order referenced in your letter. I will then address the issues and concerns raised in your August 19, 2005, correspondence in the same manner.

With respect to item 1 in your July 25 correspondence, those items appear to indicate observations of your staff and others and do not appear to require a response. I would inform you that I have been advised by my client that the hose leading from the hydrosieve area to the storm water basin exists for the purposes of pumping storm water to the hydrosieve and then into tanks. Evidence of this fact is found by the pump in the basin which pumps water out of the basin into the hydrosieve area. The reason for this is that the storm water basin does not allow for storm water to percolate through soil and, thus, in order to remove the water, it was pumped into the hydrosieve area. From your letter, it appears that DEQ staff believe that the hose existed for the purpose of pumping process wastewater into the storm water basin on a routine basis, which I am advised is not the case.

With respect to the nuisance odor issues contained in item 2 of your July 25, 2005, correspondence, these issues were addressed in my response to your office in my August 5, 2005, response. My client has gone to extraordinary cost and expense to cover the brine pits, install other containment measures, and also install a lagoon cover over the process wastewater lagoon. In addition, my client has purchased, at great expense, deodorizing misters for the wastewater tanks inside the building where the large containment tanks are located. The plain fact of the matter is that some of the neighboring property owners have vowed to make it their mission to run my client out of business by making false accusations and spurious complaints. Your staff is well aware of these false allegations and has, on many occasions, noted that no odor exists when odor complaints are made. Further, the Grand Traverse County Sheriff's Department has, likewise, responded to odor complaints, finding no cause for citation or other action. Certainly, the odor problem is not going to be made any better by my client's inability to discharge any process wastewater. Separating the pitting and stemming wastewaters currently under permit is not a workable option, as it appears that the brining and stemming wastewater exceeds permit criteria and cannot lawfully be discharged anyway. I suppose this is not the Department's problem, since it is my client's original environmental consulting engineers who made this mistake, but my client is struggling in every sense of the word to remedy this problem. Shipping the waste offsite to a disposal facility is not a workable option, since it costs nearly $30,000.00 per month to do this. Thus, for your staff to point out the option that WRS can simply tank and haul all the wastewater neglects to acknowledge any fundamental economic reality.

With respect to item 3, I've not received any response from your staff with respect to my response to you in my August 5, 2005, correspondence. Even though I cannot find specific support for the Department's position that placing wastewater in sealed brine pits with covers is a violation of the ACO, my client has, nonetheless, stopped discharging to these sealed brine pits. My client is currently gathering wastewater into tanks on the property. The storage capacity of these tanks will soon be exhausted and my client will then have to shut the business down and put over fifty people out of work, as well as eliminate one of the largest fruit processing facilities in our region as a resource for local farmers. As you are well aware, a proposal was proffered to the Department for batching, diluting and discharging wastewater to rapid infiltration basins, but that proposal has likewise been rejected.

With respect to issue 4, please be advised that my client is in the process of requesting reauthorization of their current storm water permit. My client expects to submit revised storm water documentation to the Department within the next thirty days.

With respect to the next seven enumerated items referenced on page 3 of your correspondence, please be advised that I have already responded to these issues in my August 5, 2005, correspondence to your office.

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With respect to item 7, attached please find attached as Exhibit "A" a work plan from Inland Seas Engineering for investigating and determining if any adverse impacts have occurred as a result of other discharges as referenced in your July 25, 2005, correspondence. My client also requested an interim modification of their permit to discharge, but that was likewise rejected by your staff as communicated in your August 19, 2005, correspondence. As a response to that correspondence, enclosed please find attached as Exhibit "B" a technical memorandum from my client's environmental consultant, Inland Seas Engineering. I have to say that my client was somewhat dismayed with your staff's noted deficiencies. The proposal which was presented used extraordinarily conservative assumptions and, in most cases, followed specific departmental and USEPA guidance and administrative rules for those design assumptions. It appears that your staff did not carefully review this information, as most of the noted "deficiency" issues were addressed in the proposal. Please see the technical memo for more details on this issue.

Specifically, your letter indicates at item 4, with some degree of criticism, that application rates were based on pump tests. Part 22 Administrative Rules and departmental guidance specifically indicate that pump tests are to be used to calculate this information.

Further, your August 19, 2005, correspondence notes at item 2 that WRS must provide hydrogeologic information on the actual or potential impacts of groundwater withdrawal on adjacent water supply wells. I have reviewed the Part 22 Administrative Rules, as well as other administrative rules to part 31, and I can find no legal support for the Department's position that this evaluation be undertaken. Certainly, if pending legislation is passed, then this type of evaluation would need to be completed, but there currently exists no statute or administrative rule which would require a permittee to provide this type of information.

With respect to item 3, your staff indicates a concern related to recirculating chloride impact groundwater. I responded to this concern previously by indicating that my client has two other large capacity production wells which are not impacted by chloride contaminants and, thus, these wells would be utilized for dilution water. I believe this would address item 3. As stated previously, Mr. Smits of Inland Seas Engineering, Inc. has identified other areas of technical concern related to DEQ staff comments. While I certainly would expect that my client should meet each and every legal criteria for permit issuance, it appears as though the bar is being set impossibly high and, in some cases, information is being requested which is not part of any lawful criteria. My client will attempt to address your staff's concerns through a formal permit modification request and we will attempt to work through the issues and address each and every one of your staff's concerns. However, I would expect that the process of addressing those concerns would be dictated by the statute and rules.

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Finally, your August 19, 2005, correspondence seems to indicate that my client sat blithely by while its wastewater management options were foreclosed. Nothing could be further from the truth. My client struggled at great expense to purchase ultrafiltration equipment, as well as consulting services, from a national engineering firm to get them to a point where they could completely treat their water onsite and not discharge impacted water. I would think that in most circumstances the DEQ would applaud such an effort to invest in such pollution prevention efforts. In the meantime, my client's bank account dwindled to nothing while it advanced the extraordinary costs of hauling water offsite for disposal elsewhere. It was not until April, 2005, that my client was left without an option other than to go back to a dilute and discharge alternative. With economics exhausted and their backs against the wall, my client began storing wastewater onsite. The viable option which you reference, to tank and haul wastewater, is not an economically viable option and, quite frankly, is not done by anyone in the industry.

To conclude, I am hopeful that the Department can expediently act upon my client's forthcoming permit modification request. I am, likewise, hopeful that sound principles of discretion are exercised in consideration of that permit. My client continues to attempt to address each of the issues which you and your staff have identified and will continue to attempt to meet your staff's expectations.

Please let me know if you have any additional questions or comments regarding this responsive correspondence. Accordingly, I look forward to hearing from you.

Sincerely,

ZIMMERMAN, KUHN, DARLING,
BOYD, TAYLOR AND QUANDT, PLC

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cc: Chris Hubbell
Brian Smith
Andy Smits
Barry H. Selden
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James Janiczek
Thomas Weston
Janice Heuer
Mike Stiffler

Exhibit "A"

INLAND SEAS ENGINEERING

P.O. Box 6820, Traverse City, MI 49696
1755 Barlow Street, Traverse City, MI 49686
Phone (231) 933-4041
Fax (231) 933-4393

August 31, 2005

Mr. Joseph Quandt
Zimmerman, Kuhn, Darling, Boyd, Taylor & Quandt, P.L.C.
412 South Union Street
P.O. Box 987
Traverse City, Michigan, 49685-0987

Re: Soil and Groundwater Assessment Work Plan
Cherry Blossom, LLC
**ISE Project #02061-59E**

Dear Mr. Quandt:

The purpose of this letter is to provide a Work Plan (WP) to assess the potential impacts to soil and groundwater as required by the July 25, 2005 letter from MDEQ to Williamsburg Receiving and Storage, LLC. The Consent Order required a Hydrogeologic Study WP to assess the potential impact of wastewater discharges and brining operation upon groundwater resources. The HSWP was developed and conditionally approved by MDEQ. Inland Seas Engineering, Inc. (ISE) proposes that the investigative and analytical methods to be used to assess soil and groundwater impacts in response to the July 25 demand letter comport with those in the HSWP and previously reviewed by MDEQ staff. The following WP elements deal with specific sampling details associated with each assessment area cited by MDEQ in the demand letter.

**Storm Water Retention Basin**
ISE proposes to install three monitoring wells surrounding the basin. One monitoring well will be installed between the basin and Munro Road with the remainder situated north and southeast of the basin. This will allow for assessment of groundwater quality down-gradient of the basin (in the case of the former) and provide for accurate evaluation of flow potential in the vicinity of this infiltration structure. If potentiometric measurements indicate that additional wells are required to assess groundwater quality and flow potential, then the wells will be installed following evaluation of potentiometric and analytical data. Soil samples are not proposed for this location as the discharge reportedly occurred to a structure whose basal soils are saturated during nominal operation.

**Topographic Depressions East and Southeast of Irrigation Pond**
Soil and groundwater sampling are proposed for these areas. The smaller area immediately east of the irrigation pond will be evaluated through installation of one monitoring well. Soil sampling will be conducted as the boring to install the well is advanced. Soil sample conductivities and moisture contents will be evaluated in accordance with methods used to evaluate the spray irrigation areas in 2002.

Southeast of the Irrigation Pond two (2) additional monitoring wells are proposed to be installed as described immediately above in conjunction with soil sampling and analyses. The wells will be installed during differing periods. The first well will be installed in the eastern portion of this area. Following potentiometric measurements and evaluation of flow potential (including the use of the small depression monitoring well and MW-501, MW-502 and MW-301 from the prior HS), the second well will be installed in a manner to monitor groundwater quality down-gradient of this area. Soil sampling will not be undertaken in conjunction with this latter well as it is likely to be situated beyond the wastewater application limits.

**Paradis Parcel Assessment Area**

This area presents challenges in assessment due to the non-uniform nature of reported wastewater application. Prior to soil or groundwater sampling, ISE proposes to conduct a frequency-domain electromagnetic (EM) geophysical survey. The EM survey will measure the conductivity of the earth in this area so as to identify areas of maximum and minimum terrain conductivity. This will allow efficient delineation of the probable limits of impact of a conductive wastewater over a wide (elongate) area. Depending upon the EM equipment utilized, an estimate of the depth of impact may also be gained through the same survey.

The EM survey will be followed by shallow soil sampling and analyses that will facilitate a quasi-calibration of the EM results with dissolved solids (chloride principally) content of soil moisture. In the coarse-grained soils present in this area, it is the soil moisture that will give rise to terrain conductivity anomalies. The soil matrix will act largely as an insulator to induced electrical conductance.

Concurrent with evaluation of these data, soil borings and monitoring wells will be installed in the vicinity of the Paradis "pond" and in other areas where MDEQ District Staff notes and distressed vegetation suggest pooling of wastewater may have occurred. It is estimated that five (5) monitoring wells will be installed in conjunction with this initial effort. The purpose of this element of the WP is to gain an initial understanding of gross potentiometric trends and to allow early monitoring of areas where maximum potential for impact exist, while the EM survey is serving to define the limits of further investigation. These five (5) monitoring wells will be installed in areas presumably down-gradient of visually impaired locations with perhaps two (20 of the wells installed topographically higher to provide information on background water quality and potentiometric surface trends. The attached figure shows typical monitoring locations relative to the proposed EM survey area.

**Reporting**

Following installation of initial monitoring wells and evaluation of the EM survey data a summary report will be generated providing the rationale for any further assessment required to address the requirements of the demand letter. Meeting will be sought with District MDEQ Staff to review the initial findings and plan any subsequent assessment activities. In addition, District Staff will be polled prior to execution of any portion of the WP to incorporate their observations into final work plan details. It is understood that MDEQ Staff have observed and documented the alleged discharge locations directly and can assist with this information in scoping optimal location and placement of assessment borings.

**Schedule**

ISE can commence with execution of the plan within 30 days following our authorization to proceed and completion of contract administrative matters. Based upon the nature of the subsurface assessment work and the reported discharge characteristics, it is believed that the assessment work can be completed in 150 to 180 days, weather and access permitting. Multiple potentiometric measurement events are required to evaluate groundwater flow potential and support proper placement of monitoring wells. The iterative nature of the proposed assessment suggests that the need for work in addition to that proposed herein may likely arise. Findings from subsurface investigation often require validation through repeated measurement so as to incorporate evaluation of natural processes (seasonal and temporal effects) in the assessment.

Please call me if you have any questions or comments regarding any aspect of this submittal.

Respectfully,
**INLAND SEAS ENGINEERING, INC.**

Andrew J Smits

Andrew Smits, P.E.
Geological Engineer

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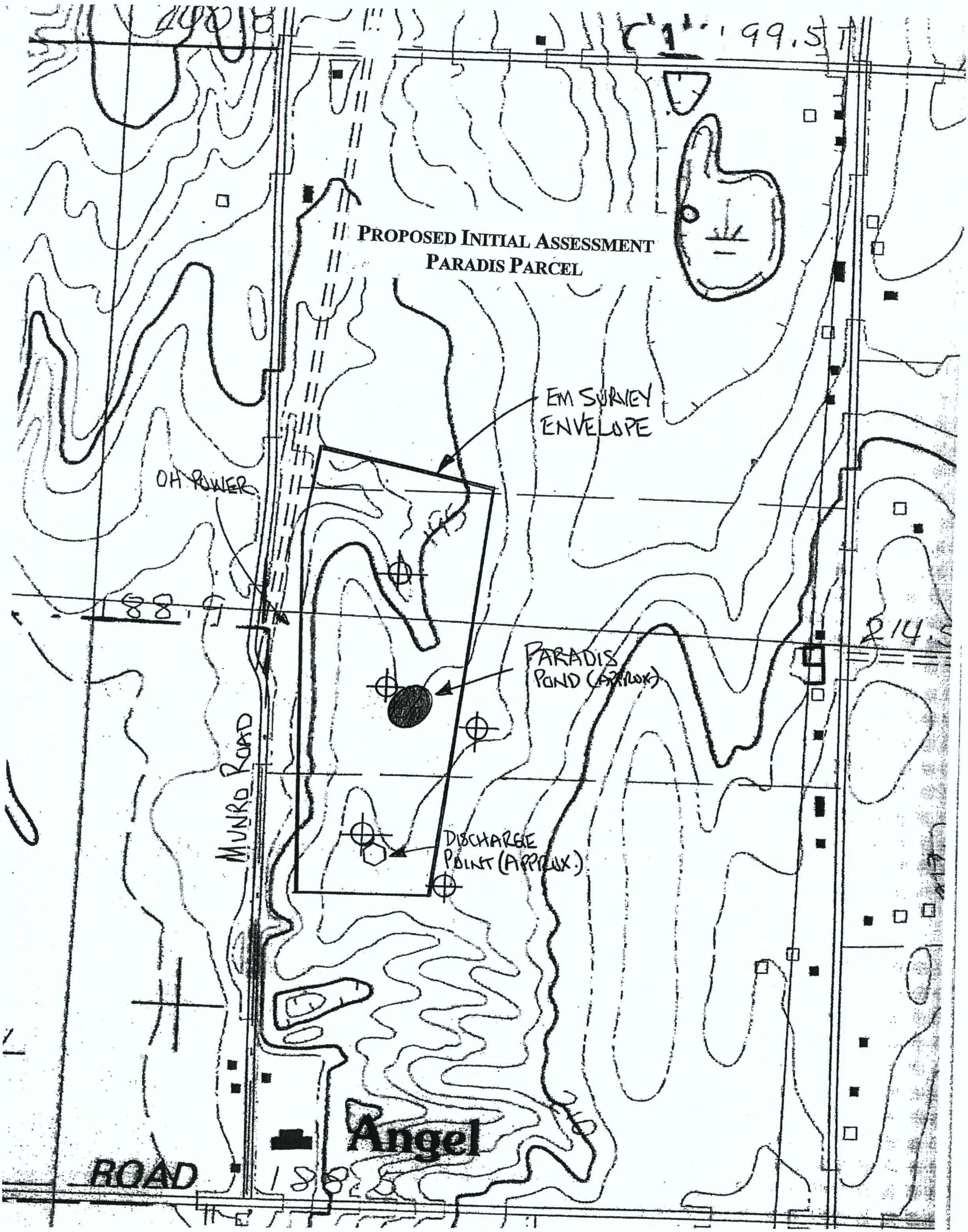

PROPOSED INITIAL ASSESSMENT
PARADIS PARCEL
EM SURVEY ENVELOPE
OH POWER
188.9
PARADIS POND (APPROX)
MUNRO ROAD
DISCHARGE POINT (APPROX.)
Angel
ROAD

Exhibit "B"

INLAND SEAS ENGINEERING

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Fax (231) 933-4393

August 30, 2005

Mr. Joseph Quandt
Zimmerman, Kuhn, Darling, Boyd, Taylor & Quandt, P.L.C.
412 South Union Street
P.O. Box 987
Traverse City, Michigan, 49685-0987

Re: Initial Technical / Regulatory Review
Preliminary Design and Operation Proposal
Rapid Infiltration Basin System
Cherry Blossom, LLC
**ISE Project #02061-57E**

Dear Mr. Quandt:

I have undertaken review of Part 22 Rules related to Preliminary Design and Operation Proposal for the Rapid Infiltration System proposed August 4th as part of a proposal to modify the Consent Order. This review is undertaken following receipt of a copy of the August 19th letter from Richard A. Powers, Water Bureau Chief, wherein MDEQ "identified deficiencies" in the initial review of the preliminary design and operations proposal. The technical/regulatory review of the cited deficiencies below will focus upon perceived deficiencies 1., 3. and 4. Perceived deficiency 2. seems to relate to a program other than Part 31 and its Part 10 and Part 22 Rules.

Attached please find excerpts from the USGS Report cited in the Hydrogeolgic Study (HS) and HS Work Plan developed for the Permittee. I believe the information contained therein is quite responsive to any concerns associated with perceived deficiency 2., regardless of the program origins. The groundwater resources studied by USGS appear ample to supply the volume of groundwater needed each day to dilute lean plant effluent. I do not understand how DEQ staff arrived at the assumption of one million gallons per day necessary for dilution. The volume proposed for land application is 76,000 gallons per day. This figure was utilized for preliminary design purposes and it more than 200 % greater than the maximum flow observed from plant operations coupled with the requisite dilution volume to reduce chloride concentrations to levels below Rule 2222.

The excerpts below from the August 4th proposal clearly indicate that "lean plant effluent" is the subject wastewater proposed for discharge in the proposed Rapid Infiltration Basins (RIBs). The excerpts indicate that lean plant effluent is to be generated through the segregation of "brine rich" plant flows from the aggregated plant effluent. You will also note that the dilution make-up water source is assumed to possess maximum concentrations of Rule 2222 and Rule 2204 analytes of interest. The USGS report indicates that these assumptions are reasonable and will likely be met by a water supply well developed in this area.

## Excerpts Condensed from August 4, 2005 Preliminary RIB Proposal

From these data, ISE has estimated dilution volumes of well water (assuming no BOD and 20 mg/L Chloride) required such that mixing with the effluent will reduce the concentrations of permit-required monitoring parameters to levels below Rule 2222 criteria. The lean plant effluent is proposed to be pumped to batching tanks provided by CB, where sufficient well water is added to attain the target effluent concentrations and to maintain necessary freeboard within tanks. Conductivity of the contained fluid will be monitored periodically to determine appropriate sampling time.

Samples of the diluted, lean plant effluent will be acquired and analyzed for permit-required constituents as well as $BOD_5$ and COD. Upon demonstration of attaining permit conditions, the dilute plant effluent will be pumped to an approved land application area within the permit-required application area as described below. If laboratory results indicate that further dilution is required, the dilution volume will be calculated from the batch laboratory results and 120% of the calculated dilution volume will be added prior to pumping to land application areas. Alternatively, additional analyses may be conducted and only 100% of the calculated dilution volume will be added.

Initial dilution volume estimates indicate that chloride concentrations in the lean plant effluent will drive dilution water volume. Segregation of spent brine and its solutions from plant effluent should yield a nominal $BOD_5$ concentration in aggregated lean plant effluent at approximately 700 milligrams per liter (mg/L), ignoring the potential for aerobic degradation within piping and pump chambers prior to containing. Dilution of this wastewater to reduce chloride concentrations is expected to further reduce BOD to approximately 400 mg/L, based upon current estimates of waste character and flow data provided by CB. Additional dilution or aeration may be warranted prior to discharge. Aeration within the RIB system will occur as influent cascades over rip-rap and is exposed to the atmosphere.

## Perceived Deficiency 1. BOD Effluent Limitations

The following tables are excerpted from the 2002 EPA Publication, On-site Wastewater Treatment Systems Manual:

**Table 3-7. Constituent mass loadings and concentrations in typical residential wastewater** [a]

| Constituent | Mass loading (grams/person/day) | Concentration[b] (mg/L) |
|---|---|---|
| Total solids (TS) | 115–200 | 500–880 |
| Volatile solids | 65–85 | 280–375 |
| Total suspended solids (TSS) | 35–75 | 155–330 |
| Volatile suspended solids | 25–60 | 110–265 |
| 5-day biochemical oxygen demand ($BOD_5$) | 35–65 | 155–286 |
| Chemical oxygen demand (COD) | 115–150 | 500–660 |
| Total nitrogen (TN) | 6–17 | 26–75 |
| Ammonia ($NH_4$) | 1–3 | 4–13 |
| Nitrites and nitrates ($NO_2$-N; $NO_3$-N) | <1 | <1 |
| Total phosphorus (TP)[c] | 1–2 | 6–12 |
| Fats, oils, and grease | 12–18 | 70–105 |
| Volatile organic compounds (VOC) | 0.02–0.07 | 0.1–0.3 |
| Surfactants | 2–4 | 9–18 |
| Total coliforms (TC)[d] | – | $10^8$–$10^{10}$ |
| Fecal coliforms (FC)[d] | – | $10^6$–$10^8$ |

[a] For typical residential dwellings equipped with standard water-using fixtures and appliances.
[b] Milligrams per liter; assumed water use of 60 gallons/person/day (227 liters/person/day).
[c] The detergent industry has lowered the TP concentrations since early literature studies; therefore, Sedlak (1991) was used for TP data.
[d] Concentrations presented in Most Probable Number of organisms per 100 milliliters.

Source: Adapted from Bauer et al., 1979; Bennett and Linstedt, 1975; Laak, 1975, 1986; Sedlak, 1991; Tchobanoglous and Burton, 1991.

**Table 5-1. Types of mass loadings to subsurface wastewater infiltration systems.**

| Mass loading type | Units | Typical loading rates |
|---|---|---|
| **Hydraulic** | | |
| • Daily | Volume per day per unit area of boundary surface | Septic tank effluent: 0.15–1.0 gpd/ft² (0.6–4.0 cm/d) Secondary effluent: 0.15–> 2.0 gpd/ft² (0.6–>8.0 cm/d) |
| • Instantaneous | Volume per dose per unit area of boundary surface | 1/24–1/8 of the average daily wastewater volume |
| • Contour (Linear) | Volume per day per unit length of boundary surface contour (which can be a critical design parameter in areas with high water tables) | Depends on soil $K_{sat}$*, maximum allowable thickness of saturated zone, and slope of the boundary surface (see section 5.3) |
| **Constituent** | | |
| • Organic | Mass of BOD per day per unit area of boundary surface | 0.2–5.0 lb BOD/1000 ft² (1.0–29.4 kg BOD/1000 m²) |
| • Other pollutants | Mass of specific wastewater pollutant of concern per unit area of boundary surface (e.g., number of fecal coliforms, mass of nitrate nitrogen, etc.) | Variable with the constituent, its fate and transport, and the considered risk it imposes |

*$K_{sat}$ is the saturated conductivity of the soil.
Source: Otis, 2001.

From the above tables it is understood that typical residential daily wastewater BOD load is typically 0.2 to 5.0 pounds of BOD per thousand square feet and typical domestic effluent BOD ranges from 150 to 250 mg/L. It is noteworthy that BOD source from domestic wastewater is considerably more complex than the simple sugars comprising the BOD load from the Cherry Blossom wastewaters.

The table (Table 1) included in the August 4th proposal included a lean plant effluent volume of 32,796 gallons (124,626 liters) at a BOD concentration estimate of 400 mg/L. This equates to 50 kilograms (23 pounds) of BOD per day within the lean plan effluent. The RIB unit basin size proposed in the preliminary plan was 900 square feet (3 or 4 units were proposed to allow for basin resting). Dividing the daily BOD load (23 pounds) by 900 square feet yields a BOD load per square foot, which is greater than typical septic system effluent minimum loading.

Utilizing the BOD target value proposed by MDEQ (100 mg/L) as an effluent limitation. One can calculate that the lean plant effluent would require additional dilution water totaling 131,000 gallons per day (approximately 3 additional parts dilution water : diluted lean plant effluent). This additional dilution volume applied over 900 square feet yields an application rate of 145 gallons per day per square foot. The preliminary design effluent application rate was given as 168 gallons per day per square foot of land surface applied.

It is clear from cursory computations that proposed BOD loading rates suggested by MDEQ comport with typical domestic wastewater loading to subsurface soils. It is also clear that the MDEQ effluent limitation suggestion can be achieved by additional dilution and land application, without any modification to the preliminary design proposed. I would highlight that the proposed application mode is sub-aerial (as opposed to subsurface) allowing atmospheric oxygen supply and neglects any BOD treatment that was clearly proposed in the August 4th submittal as a possible BOD reduction method.

**Perceived Deficiency 3.- Dilution Source Water**
The proposal included (see page 2, August 4th preliminary design) operation of the RIB such that effluent would be characterized by laboratory analyses prior to land application to ensure that the effluent dilution was appropriate to meet Rule 2222 criteria. Thus concerns regarding the effect of source water upon aquifer chloride concentrations are addressed. Considering MDEQ's preference for a 100 mg/L effluent limitation for BOD and the consequential addition of dilution water, chloride concentrations resulting from further BOD reductions (dilution only) would be correspondingly reduced by 300% to approximately 50 mg/L. You may note from the USGS study, this is within an order of magnitude of the mean local and statewide chloride concentrations in groundwater (5 mg/L). Note that this 50 mg/L concentration is prior to mixing and dilution in the aquifer. No adverse impact to groundwater quality is evident from initial evaluation of the August 4th preliminary design.

**Perceived Deficiency 4.- Hydraulic Loading**
Rule 323.2233(4)(a) prescribes system designed and operation methods. Land application rates to solum under (4)(a)(v) are limited to 7% of the permeability as determined by saturated hydraulic conductivity (aquifer pump test) methods. The proposed preliminary design included the removal of solum (the layer limiting hydraulic conductivity) and application rates determined by site-specific saturated hydraulic conductivity testing. The 7% limitation from rule 323.2233(4)(a)(v)was used to reduce the hydraulic conductivity to the proposed land application rate.

This was further reduced this by doubling the basin application areas proposed (and included a future replication of the 4-unit concept in the conceptual design). I also proposed basin infiltration testing using the actual wastewater (EPA recommended practice) during initial application of wastewater basins designed in accordance with Part 22 rules and with a factor of safety exceeding 200%. Coupling the safety factors incorporated into the preliminary design, one would recognize a conservative design approach is employed when realizing that the hydraulic load rate proposed is 28 times less than the rate that site-specific testing indicates is possible.

The entire development was proposed to be located within the area where four (4) HS borings sampled 100% of the upper 20 feet of soil and a considerable fraction of soil below this depth until the water table was encountered. I can recall no other project where the soils were so thoroughly characterized prior to subjecting them to further testing and monitoring as the proposal suggested.

I still believe that the preliminary design, operation and maintenance information provided in the August 4th proposal was sufficient to elicit appropriate comment from MDEQ prior to more detailed engineering development of the concept. No questions or comments were fielded from MDEQ in the matter prior to the issuance of the August 19th response. The simple calculations and references above (and attached) are, in my opinion, sufficient to alleviate any technical or regulatory concerns related to Part 31 programs. It may well be that the accelerated nature of the submittal and its accelerated review inhibited objective evaluation of the technical and regulatory merits of the proposed RIB concept. The RIB approach should be pursued as part of Permit Modification Petition efforts, due to the efficiencies it presents in land use and resulting savings in infrastructure costs relative to spray irrigation.

Please call me if you have any questions or comments regarding any aspect of this submittal.

Respectfully,
INLAND SEAS ENGINEERING, INC.

Andrew J Smits

Andrew Smits, P.E.
Geological Engineer

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# HYDROLOGY AND LAND USE IN GRAND TRAVERSE COUNTY, MICHIGAN

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 90-4122

Prepared in cooperation with

GRAND TRAVERSE COUNTY and the
MICHIGAN DEPARTMENT OF NATURAL RESOURCES
GEOLOGICAL SURVEY DIVISION

Exemption 9 applies to pages 15-17

[redacted]

Table 28.--Comparison of ground-water quality in Grand Traverse County with statewide ground-water quality

[mg/L, milligrams per liter; µg/L, micrograms per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; <, less than; °C, degrees Celsius]

| Constituent or property | Median concentration | |
|---|---|---|
| | [a]Statewide | [b]Grand Traverse County |
| Alkalinity (mg/L as $CaCO_3$) | 155 | 180 |
| Arsenic, total (µg/L as As) | 1 | <1 |
| Calcium, dissolved (mg/L as Ca) | 50 | 58 |
| Chloride, dissolved (mg/L as Cl) | 4.4 | 5.5 |
| Chromium, total recoverable (µg/L as Cr) | <20 | <10 |
| Fluoride, dissolved (mg/L as F) | .1 | <.1 |
| Hardness, total (mg/L as $CaCO_3$) | 200 | 200 |
| Hardness, noncarbonate (mg/L as $CaCO_3$) | 12 | 18 |
| Iron, total recoverable (µg/L as Fe) | 560 | 175 |
| Manganese, total recoverable (µg/L as Hg) | 22 | 20 |
| Magnesium, dissolved (mg/L as Mg) | 17 | 13 |
| Mercury, total recoverable (µg/L as Hg) | <.50 | <.1 |
| Nitrogen, ammonia, total (mg/L as N) | .05 | .03 |
| Nitrogen, nitrate, total (mg/L as N) | .01 | .09 |
| Nitrogen, nitrite, total (mg/L as N) | <.01 | <.01 |
| Nitrogen, organic, total (mg/L as N) | .13 | .17 |
| pH (standard units) | 7.7 | 7.7 |
| Phosphorus, total (mg/L as P) | <.01 | .01 |
| Phosphorus, ortho, total (mg/L as P) | <.01 | .01 |
| Potassium, dissolved (mg/L as K) | 1.4 | .7 |
| Selenium, total (µg/L as Se) | <1 | <1 |
| Silica, dissolved (mg/L as $SiO_2$) | 11 | 7.6 |
| Silver, total recoverable (µg/L as Ag) | <1 | <1 |
| Sodium, dissolved (mg/L as Na) | 6.8 | 2.0 |
| Solids, residue at 180°C, dissolved (mg/L) | 244 | 200 |
| Solids, sum of constituents, dissolved (mg/L) | 240 | 205 |
| Specific conductance (µS/cm)) | 426 | 413 |
| Strontium, total recoverable (µg/L as Sr) | 150 | 40 |
| Sulfate, dissolved (mg/L as $SO_4$) | 13 | 13 |
| Temperature (°C) | 9.5 | 9.0 |
| Zinc, total recoverable (µg/L as Zn) | 60 | 235 |

[a] Cummings, 1989.
[b] This investigation.

Table 26.--Chemical and physical characteristics of ground water--Continued

| Well number | Silica, dis- solved (mg/L as $SiO_2$) | Calcium, dis- solved (mg/L as Ca) | Magne- sium, dis- solved (mg/L as Mg) | Sodium, dis- solved (mg/L as Na) | Potas- sium, dis- solved (mg/L as K) | Sulfate, dis- solved (mg/L as $SO_4$) | Chlo- ride, dis- solved (mg/L as Cl) | Fluo- ride, dis- solved (mg/L as F) |
|---|---|---|---|---|---|---|---|---|
| B1 | 8.1 | 80 | 17 | 1.6 | 0.6 | 36 | 15 | <0.1 |
| B2 | 17 | 63 | 17 | 6.6 | .9 | 0.4 | .7 | .4 |
| B3 | 8.0 | 65 | 18 | 1.7 | .7 | 13 | .9 | <.1 |
| B4 | 7.0 | 53 | 13 | 1.0 | .4 | 9.7 | 1.8 | <.1 |
| B5 | 7.2 | 43 | 9.1 | 1.2 | .5 | 6.2 | .8 | <.1 |
| B6 | 10 | 65 | 16 | 1.7 | .5 | 20 | 1.9 | .2 |
| B7 | 12 | 70 | 18 | 2.6 | .6 | 27 | .9 | .7 |
| B8 | 8.7 | 52 | 11 | 2.4 | .5 | 12 | .7 | .3 |
| B9 | 5.0 | 56 | 9.6 | .6 | .5 | 9.5 | .6 | <.1 |
| B10 | 7.7 | 60 | 11 | 1.3 | .4 | 7.3 | .7 | <.1 |
| B11 | 7.1 | 39 | 8.0 | 3.0 | .3 | 2.0 | 2.8 | <.1 |
| B12 | 9.0 | 63 | 15 | 1.9 | .7 | 20 | .7 | .2 |
| B13 | 7.3 | 72 | 15 | 3.0 | 1.0 | 14 | 24 | .1 |
| B14 | 3.7 | 20 | 4.6 | .5 | .6 | 6.9 | .6 | <.1 |
| B15 | 7.3 | 55 | 13 | 1.1 | .5 | 11 | .7 | <.1 |
| B16 | 5.5 | 31 | 6.6 | 14 | 1.0 | 13 | 27 | <.1 |
| B17 | 9.4 | 57 | 12 | 2.0 | .5 | 12 | 2.3 | <.1 |
| B18 | 6.8 | 100 | 21 | 1.5 | 1.5 | 19 | 12 | <.1 |
| B19 | 6.3 | 53 | 12 | 10 | 1.0 | 18 | 28 | <.1 |
| B20 | 9.7 | 61 | 17 | 3.3 | .7 | 14 | 2.2 | .3 |
| B21 | 8.4 | 68 | 18 | 5.6 | .8 | 16 | 9.1 | <.1 |
| G1 | 12 | 180 | 47 | 7.2 | 1.3 | 72 | 47 | .2 |
| G2 | 12 | 61 | 20 | 5.6 | 1.0 | 26 | 7.1 | .1 |
| G3 | 7.0 | 57 | 13 | 1.7 | .9 | 14 | 3.0 | <.1 |
| G4 | 6.3 | 53 | 9.9 | .9 | .5 | 9.0 | .8 | <.1 |
| G5 | 9.4 | 40 | 7.5 | 2.0 | .8 | 1.3 | 2.5 | .2 |
| G6 | 7.1 | 32 | 7.7 | 1.3 | .0 | 7.3 | .6 | .0 |
| G7 | 3.9 | 38 | 5.0 | 11 | .0 | 11 | 5.9 | .0 |
| G8 | 13 | 35 | 12 | 24 | .0 | .5 | 19 | .0 |
| G9 | 8.8 | 93 | 24 | 2.6 | 1.7 | 18 | 1.9 | <.1 |
| G10 | 7.2 | 100 | 23 | 9.2 | 7.5 | 18 | 31 | <.1 |
| G11 | 8.9 | 81 | 19 | 2.0 | .9 | 16 | 1.6 | <.1 |
| G15 | 6.5 | 89 | 20 | 2.6 | 2.7 | 20 | 29 | <.1 |
| GP-1 | 7.5 | 46 | 13 | 1.4 | .7 | 11 | 1.2 | <.1 |

rainfall. Seasonal water-level peaks usually occur between late May and early July. Occasionally, a second peak occurs in late autumn when rainfall increases and evapotranspiration decreases.

## Depth and Yield of Water-Bearing Deposits

Plate 3 is a map showing generalized depth to water-bearing deposits in Grand Traverse County. The map indicates the depth to which a well must be drilled within the glacial deposits to obtain a domestic water supply of 10 gal/min (gallons per minute). If the hydraulic properties of the glacial deposits near the water table are unsatisfactory, depth of drilling may need to be increased to find a water-bearing zone. These zones are usually coarse-grained sand and gravel deposits.

In general, outwash and lacustrine deposits are coarse-grained. Wells installed in these deposits are usually shallow because the water table is close to the land surface. Where outwash or lacustrine deposits are present, most wells are less than 100 ft deep. Confining units are usually not present in these areas at shallow depths.

Fine-grained materials, associated with till and distal lacustrine deposits, are found in parts of the county where moraines are present. Wells in these areas range from 100 to 300 ft deep and generally have low yields. At least one confining unit usually is present, but the deepest wells will penetrate through multiple confining units to reach a productive zone.

Depth to water is related to type of glacial deposit in the county. The highest land-surface elevations and greatest topographic relief are associated with morainal deposits; the depth to water in these areas is greater than in areas of outwash deposits. Even though some of the deposits are coarse grained and could yield water to wells, they are above the water table. Outwash and lacustrine deposits are associated with low topographic relief and low land-surface elevations. Depth to water is less in these areas than in moranial areas. In a few areas where the water table is only a few feet below land surface, coarse-grained deposits sufficient to store water are not present.

Domestic wells in most of the county obtain sufficient supplies from wells 50 to 150 ft deep. These wells usually have a 4-in.-inside diameter casing, a screened interval of 4 ft, and yield at least 20 gal/min. Irrigation, municipal, and industrial wells are usually 150 to 450 ft deep and are capable of yielding 250 gal/min or more. These wells have at least a 6-in.-inside diameter casing and have a much greater screened interval in the water-bearing zone than do domestic wells.

## Hydraulic Properties of Aquifers

The only bedrock units in the county that may have potential for providing usable supplies of water are the sandstones of the Marshall Formation. Because of the depth at which the Marshall Formation lies and because the formation is not tapped for water supplies, no hydrogeologic data regarding the formation were collected during this study. Other bedrock units that underlie the glacial deposits are thought to be as poor aquifers in Grand Traverse County as they are in other parts of the State because they consist principally of shales.

The hydraulic properties of the glacial deposits depend on the type of deposit. Aquifer tests were conducted at two locations during this study to determine the horizontal hydraulic conductivity and specific yield of glaciofluvial deposits. The tests were conducted north of Fife Lake (well FL) and south of Karlin (well GP1) (plate 1). The transmissivity of deposits at well FL was 4,300 $ft^2/d$ (feet squared per day); the specific yield was 0.30. The transmissivity of deposits at well GP1 was 2,500 $ft^2/d$; the specific yield was 0.25. Hydraulic conductivities were 80 and 50 ft/d (feet per day) for wells FL and GP1, respectively. Aquifer-test data from previous investigations are available at the Village of Kingsley and at the U.S. Coast Guard Air Station, Traverse City. Analysis of the aquifer test conducted at the Village of Kingsley for a public-supply well indicates transmissivity ranges from about 3,000 to 3,800 $ft^2/d$ for the leaky confined sand and gravel aquifer. Hydraulic conductivities determined for the aquifer range from 55 to 70 ft/d. Analysis of the aquifer test made at the U.S. Coast Guard Air Station indicates that transmissivity ranges from 1,800 to 2,600 $ft^2/d$ for the unconfined sand and gravel aquifer. Horizontal hydraulic conductivity calculated from the transmissivity ranges from 100 to 150 ft/d. No aquifer tests have been conducted in fine-grained deposits such as till or lacustrine clay.

The velocity of horizontal ground-water flow depends on the hydraulic gradient, the hydraulic conductivity, and the effective porosity of the aquifer. Near well FL, the velocity of ground water is about 1 ft/d. At the U.S. Coast Guard Air Station, velocities ranged from 3 to 6 ft/d because of comparatively steep gradients, high hydraulic conductivities, and low effective porosities.

## WATER QUALITY AND LAND USE

In Grand Traverse County, as in other parts of Michigan and the country, the relation of land use to the chemical and physical characteristics of water is not always evident. To investigate possible relations in Grand Traverse County, current information on the chemical inputs to the hydrologic system, particularly the nitrogen input, was considered essential. Data on fertilizer applications, animal wastes, septic-tank discharges, and chemical composition of precipitation were compiled as the first step in evaluating water quality.

### Inventory of Land Use

The Michigan Department of Natural Resources' Division of Land Resource Programs is responsible for implementing the Michigan Resource Inventory Act of 1979. One requirement of the act is that a current-use inventory of each county be maintained. Land use or land cover is classified using 46 catagories, which are designed to identify existing use of every 2.5- to 5.0-acre area of land in the State. Land use or cover exceeding 4 percent of the total area of Grand Traverse County include: northern hardwood forest land, 24.73 percent; cropland, 16.14 percent; mixed pine forest land, 14.63 percent; herbaceous openland, 10.68 percent; orchards, 5.19 percent; single-family duplex, 4.56 percent; and lowland hardwoods, 4.15 percent (Michigan Department of Natural Resources, written commun., March 27, 1985). Table 4 lists land-use data for Grand Traverse County by township. Although data tabulated in table 4 are accurate indications of land classification, the actual area in a township devoted to a given use may be substantially less than that falling within a classification. In order to relate water quality to agricultural use, and in order to provide a basis for estimating chemical inputs to the hydrologic system, the Grand Traverse County Extension Service compiled information on the amount of field and fruit crops grown in each township in 1988. These data are given in table 5.

Table 4.--Land-use data for Grand Traverse County

[$mi^2$, square miles; percent, percentage of total area]

| Township or city | Residential, mobile home parks | | Business district, shopping center, commercial, institutional | | Industrial | | Transportation, communications, utilities | | Cropland, confined feeding operations, permanent pasture, other agricultural lands | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $mi^2$ | Percent | $mi^2$ | Percent | $mi^2$ | Percent | $mi^2$ | Percent | $mi^2$ | Percent |
| Acme | 1.65 | 6.75 | 0.21 | 0.85 | 0.042 | 0.17 | 0.095 | 0.39 | 5.54 | 22.82 |
| Blair | 1.80 | 4.99 | .19 | .53 | .11 | .30 | .016 | .04 | 7.12 | 19.74 |
| Grant | .61 | 1.69 | .0094 | .03 | .00 | .00 | .00 | .00 | 11.90 | 32.94 |
| East Bay | 3.54 | 8.30 | .24 | .56 | .00 | .00 | .16 | .37 | 3.97 | 9.32 |
| Fife Lake | .53 | 1.46 | .084 | .24 | .00 | .00 | .00 | .00 | 3.96 | 11.00 |
| Garfield | 3.22 | 11.49 | .68 | 2.43 | 1.07 | 3.80 | .081 | .29 | 8.28 | 29.51 |
| Green Lake | 1.88 | 5.34 | .41 | 1.17 | .036 | .10 | .13 | .36 | 1.67 | 4.75 |
| Long Lake | 2.42 | 6.80 | .029 | .08 | .00 | .00 | .00 | .00 | 7.37 | 20.72 |
| Mayfield | .068 | .19 | .014 | .04 | .0045 | .01 | .00 | .00 | 18.17 | 50.10 |
| Paradise | .73 | 1.39 | .086 | .15 | .00 | .00 | .11 | .28 | 10.86 | 20.53 |
| Peninsula | 2.69 | 9.33 | .033 | .12 | .041 | .14 | .00 | .00 | .22 | .76 |
| Union | .11 | .30 | .00 | .00 | .00 | .00 | .00 | .00 | .17 | .48 |
| Whitewater | 1.08 | 2.19 | .046 | .09 | .012 | .02 | .24 | .49 | 3.82 | 7.75 |
| Traverse City | 2.86 | 35.71 | 1.27 | 15.79 | .66 | 8.20 | 1.15 | 14.31 | .13 | 1.62 |

Table 4.--Land-use data for Grand Traverse County--Continued

| Township or city | Orchards, bush fruits, vineyards, horticulture area | | Herbaceous openland | | Northern hardwood, aspen/birch, lowland hardwood, pine, other upland conifers, lowland conifers, managed christmas tree plantation | | Streams and waterways, lakes, reservoirs | | Other uses | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $mi^2$ | Percent | $mi^2$ | Percent | $mi^2$ | Percent | $mi^2$ | Percent | $mi^2$ | Percent |
| Acme | 4.60 | 18.94 | 3.24 | 13.34 | 6.26 | 25.76 | 0.14 | 0.59 | 2.70 | 10.39 |
| Blair | .55 | 1.52 | 6.95 | 19.29 | 17.00 | 47.16 | .35 | .97 | 1.97 | 5.46 |
| Grant | .00 | .00 | 3.36 | 9.28 | 18.33 | 50.54 | .73 | 2.02 | 1.27 | 3.50 |
| East Bay | 1.11 | 2.61 | 4.41 | 10.34 | 23.82 | 55.85 | 2.50 | 5.86 | 2.90 | 6.79 |
| Fife Lake | .00 | .00 | 2.00 | 5.55 | 26.03 | 72.32 | 1.24 | 3.43 | 2.16 | 6.00 |
| Garfield | .94 | 3.35 | 4.40 | 15.67 | 5.34 | 19.03 | 1.03 | 3.69 | 3.01 | 10.74 |
| Green Lake | .030 | .09 | 3.54 | 10.09 | 17.60 | 50.12 | 6.34 | 18.05 | 3.49 | 9.93 |
| Long Lake | .19 | .53 | 4.21 | 11.83 | 13.65 | 38.36 | 5.83 | 16.38 | 1.88 | 5.30 |
| Mayfield | .00 | .00 | 3.27 | 9.02 | 12.74 | 35.12 | .15 | .40 | 1.87 | 5.12 |
| Paradise | .12 | .22 | 7.17 | 13.56 | 30.84 | 58.31 | .058 | .11 | 2.92 | 5.45 |
| Peninsula | 14.28 | 49.54 | 2.27 | 7.88 | 6.97 | 24.17 | .88 | 3.06 | 1.44 | 5.00 |
| Union | .00 | .00 | 1.55 | 4.29 | 32.25 | 89.32 | .19 | .54 | 1.83 | 5.07 |
| Whitewater | 3.33 | 6.74 | 4.89 | 9.91 | 30.91 | 62.62 | .54 | 1.10 | 4.49 | 9.09 |
| Traverse City | .0097 | .12 | .50 | 2.35 | .57 | 7.10 | .32 | 3.97 | .55 | 10.83 |

Table 5.--Field and fruit crops, by township, 1988

[Values shown are in acres. --, crop not grown, Data from Grand Traverse County Extension Service]

| Township | Alfalfa | Corn | Wheat | Oats | Barley | Rye | Green beans | Sweet corn | Cherries | Apples | Plums | Miscel-laneous fruits |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Acme | 644 | 860 | 27 | 34 | -- | -- | -- | -- | 2,426 | 253 | 94 | 50 |
| Blair | 155 | 339 | 9 | 26 | -- | 12 | 158 | -- | -- | -- | -- | -- |
| East Bay | 386 | 157 | -- | -- | -- | 12 | -- | -- | 388 | 38 | 15 | 8 |
| Fife Lake | 105 | 171 | 59 | -- | -- | 7 | -- | -- | -- | -- | -- | -- |
| Garfield | 465 | 400 | -- | 50 | -- | 15 | -- | 9 | 485 | 63 | 19 | 10 |
| Grant | 1,513 | 2,875 | 546 | 241 | 6 | 55 | 852 | 14 | -- | -- | -- | -- |
| Green Lake | 65 | 81 | 9 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Long Lake | 355 | 422 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Mayfield | 1,602 | 2,932 | 831 | 175 | 13 | 100 | 1,408 | 11 | -- | -- | -- | -- |
| Paradise | 3,074 | 1,474 | 168 | 161 | -- | 30 | 666 | -- | -- | -- | -- | -- |
| Peninsula | -- | -- | -- | -- | -- | -- | -- | -- | 5,335 | 570 | 208 | 110 |
| Union | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Whitewater | 564 | 260 | 26 | 23 | -- | -- | -- | -- | 873 | 253 | 34 | 18 |

## Irrigation of Agricultural Land

Irrigation of land in Grand Traverse County is not as extensive as it is in some Michigan counties. According to Bedell and Van Til (1979) there were 63 irrigators countywide in 1977. About 2,080 acres were irrigated in the county in 1985 (Van Til, Michigan Department of Natural Resources, written commun., 1985). On a daily basis, 360,000 gal (gallons) of water are withdrawn, 89 percent of which are obtained from ground-water sources. Figure 11, based on data provided by the Grand Traverse County Extension Service, shows the distribution of irrigated acreage in the county in 1987. Most irrigation is subsurface or trickle; only 8 to 10 percent of water is applied by spraying.

## Collection of Water-Quality Data

In the spring of 1984, a reconnaissance of Grand Traverse County was made to select locations at which surface water-quality data would be collected. Twenty-four sites, numbered 1 to 24 (pl. 1), were selected for periodic sampling. Beginning in June 1984, samples were collected monthly at 15 of the

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[redacted]

sites and analyzed for total[1] ammonia, total nitrite, total nitrate, total organic nitrogen, total phosphorous, total orthophosphorous, and suspended sediment. At times during the investigation, concentrations of dissolved and total nitrogen and phosphorous were simultaneously measured to determine the fraction transported in the dissolved and suspended phases at the 15 sites. At an additional nine sites, samples were collected three to eight times during the study for the same nitrogen and phosphorous analyses. At the time of sampling, specific conductance, temperature, pH, and dissolved-oxygen concentration were measured. A discharge measurement, necessary for load and runoff computations, was made at the time of sampling. Comprehensive chemical analyses of surface water, which included the major dissolved substances and trace metals, were made on samples collected at 15 sites during high and low flow conditions (table 6, at back of report). Pesticide concentrations were measured at 15 stream sites. Chemical and physical characteristics of water from 15 lakes, numbered L1 to L15, were also measured.

Water from 34 wells drilled for this project was analyzed for major dissolved substances, trace metals, and pesticides. At 211 locations, water was collected from domestic wells and analyzed for nitrate and chloride by the U.S. Geological Survey; specific conductance was measured at the time of sampling. The Michigan Department of Public Health provided 596 analyses of water from wells from their files. These analyses commonly include determinations of specific conductance, iron, sodium, nitrate, hardness, chloride, and fluoride.

Water quality of precipitation was measured at a site established near Kingsley (pl. 1). Sixty-four analyses of pH and specific conductance of rainfall and snow were made; 34 analyses of sulfate, nitrogen compounds, and phosphorus were made.

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[1] In this report, individual nitrogen compounds are referred to as "total" when laboratory analysis measured both the suspended and dissolved fractions of the compound in an unfiltered sample. "Dissolved" preceeding an individual compound indicates that the sample was filtered through a 0.45 µm (micrometer) filter at streamside, and thus the analytical result indicates that amount of the compound transported in solution. All nitrogen compounds, whether dissolved or total, are reported "as nitrogen" or "as N". As "nitrogen" or "as N" also apply in those discussions where neither the total or dissolved designation is appropriate. "Total nitrogen" or "dissolved nitrogen" indicates the sum of each of the individual compounds reported as N; "total" and "dissolved" are applied to phosphorus compounds in the same manner. All measured values are reported "as phosphorus" or "as P".